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GB 0839044 A JP 020153076 A SU 000875491 A
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UK CL (Edition K) C7B, H1N, H2A, H2E
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(54) **Sliding contactor for electric equipment**

(57) A movable electrical contactor having a surface thereof in slidable contact with a mating conductor, the surface being coated with a composite material in which particles of graphite (C) are dispersed in a matrix of silver (Ag). The coating film in one example, is formed by electric plating using a plating liquid of metal silver in the range of 2 - 100g/l in concentration, potassium cyanide in the range of 2 - 250g/l, potassium hydroxide in the range of 0.5 - 15g/l, graphite powder in the range of 1 - 55g/l, and a dispersant for dispersing graphite powder into the plating liquid in the range of 10 - 2000ppm.

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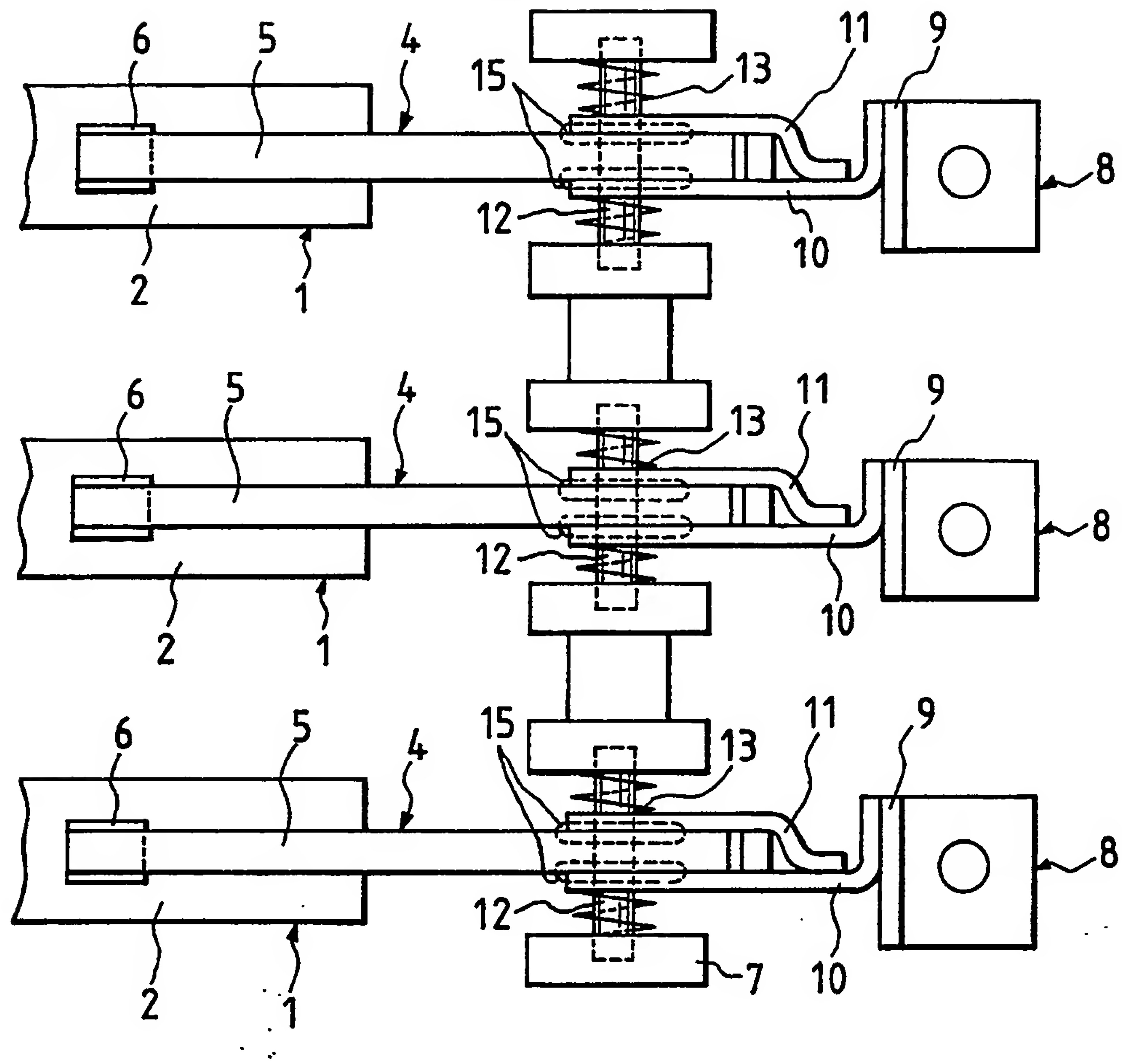


FIG. 1(A)

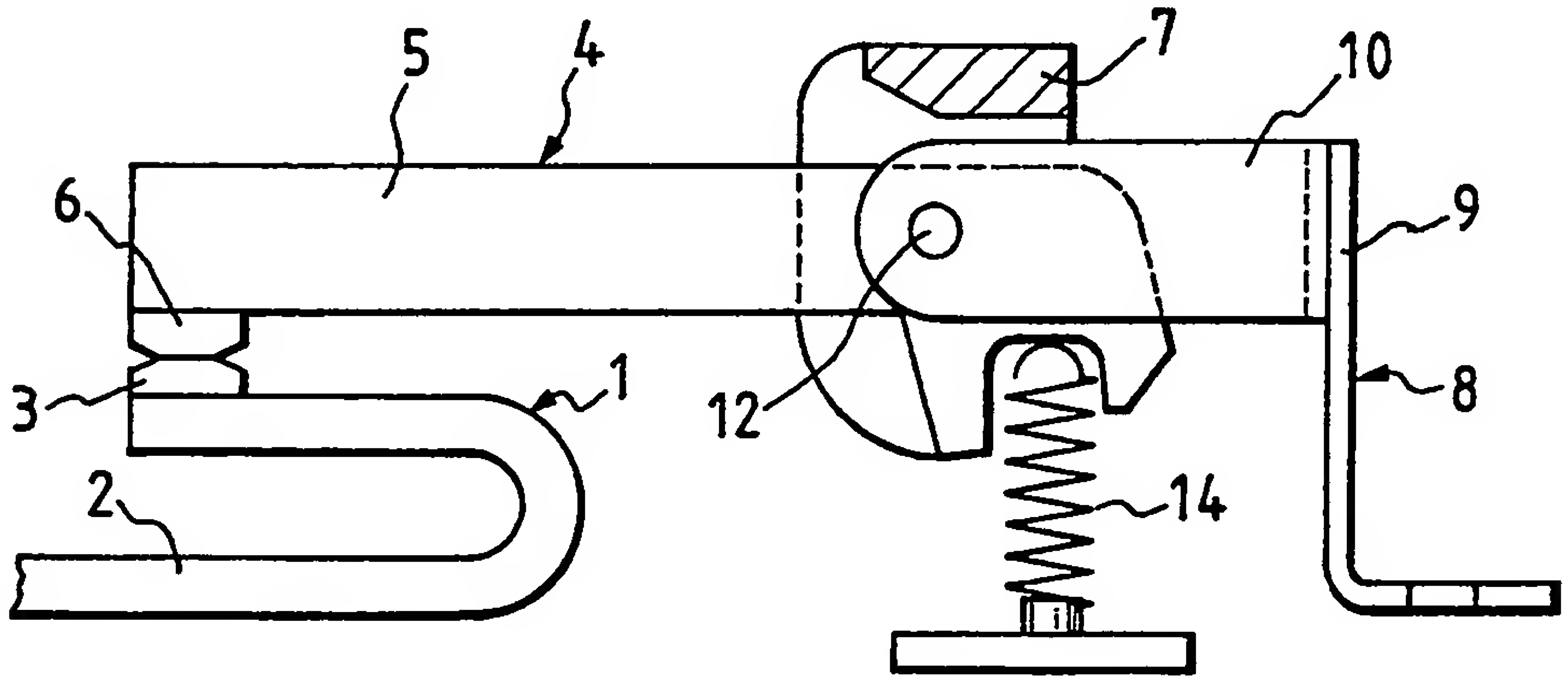
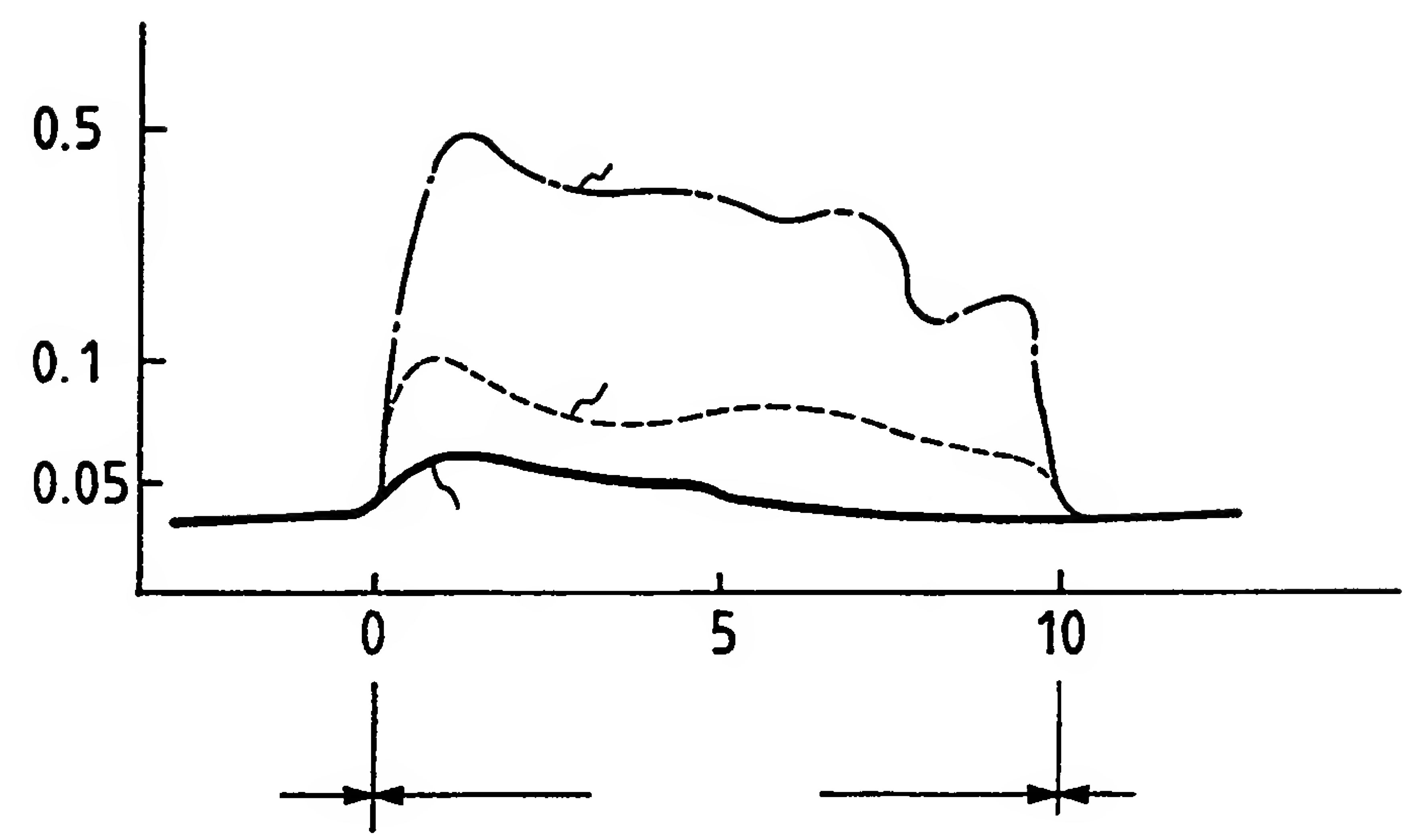


FIG. 1(B)

FIG. 2

FIG. 3



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SLIDING CONTACTOR FOR ELECTRIC EQUIPMENT

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to slidable contacts for connecting electric conductors in various electric equipment, such as circuit breakers or the like. More particularly, the invention concerns an improved surface treatment of such slidable contacts.

Description of the Related Art

In electric equipment such as circuit breakers, a disconnecting contact, a load switch, a connector, or the like, having a mechanically movable electric conductive portion, slidable contacts are used between movable and fixed conductor portions.

In the region of relative conductor movement, contacting conductive surfaces are momentarily changed during relative sliding movement so that contact resistance becomes unstable and tends to be high during relative surface movement by comparison with that in a stationary state. As a result of the increased contact resistance, the contacting surface portions are heated by electrical energy. If the contacting surfaces are made of copper or a copper alloy, surface oxidation occurs, the contact resistance is made higher by oxidation which, in turn, promotes further oxidation until the conductive surfaces no longer function as such. Conventionally, therefore, in devices designed to handle large current flow, the sliding contact surfaces are plated with silver (Ag) to prevent or at least reduce the oxidation.

Ag-plating, however, is so soft that it is subject to galling,

and is worn away even under no-load switching to expose the foundation conductor. Further, Ag is softened by electrical heat during current conduction, leading to increased galling, and possible separation of the plating layer. Moreover, under high current loads, the contacting surface portions can be fused by heat generation. Although the heat generation can be suppressed to a certain extent by increasing the contact force of the sliding contact surfaces, movement of the slidable contact surfaces becomes more difficult with increased contact force, thus requiring increased sizes of drive mechanisms and spring mechanisms for increasing the contact force. Further, as the contact force is increased, the frictional force between the sliding conductive surfaces increases and results in abrasion of the plating layer irrespective of current loads.

To cope with the foregoing phenomenon, conductive grease has been applied to an Ag-plating coating film of the sliding contacts. Although intended to prevent galling and to stabilize contact resistance, experiments conducted by the present inventors have demonstrated that the use of such grease increased contact resistance during sliding of the contact surfaces, and that when a large current load is incurred, the Ag-plating film coated with grease tended to fuse more than the same contacts not coated with grease. Further, the grease has a tendency to become hardened after use for a long time at a high temperature.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above circumstances and has as an object to provide a sliding contact in which the contact resistance is so low that stable current conduction can be obtained even during sliding movement of the contacts.

Additional objects and advantages of the invention will be set forth in part in the description which follows and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims

To achieve the objects and in accordance with the purpose of the invention, as embodied and broadly described herein, the movable electric contactor of this invention comprises a contactor having a surface thereof in slidable contact with a mating conductor, the surface being coated with a composite material in which particles of graphite (C) are dispersed in a matrix of silver (Ag) and characterized in that the coating film is formed by electric plating using a plating liquid comprising metal silver in the range of 2 - 100g/ℓ in concentration, potassium cyanide in the range of 2 - 250g/ℓ, potassium hydroxide in the range of 0.5-15g/ℓ, graphite powder in the range of 1 - 55g/ℓ, and a dispersant for dispersing graphite powder into plating liquid in the range of 10 - 2000ppm.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification illustrate an embodiment of the invention and, together with the description, serve to explain the objects, advantages and principles of the invention. In the drawings,

Fig. 1(A) is a plan view showing the movable contactor portion of a circuit breaker to which the present invention is applied;

Fig. 1(B) is a side view of the same;

Fig. 2 is an electron microscopic photograph showing the metal construction of the sliding contact portion of Fig. 1; and

Fig. 3 is a diagram showing resistance measurements of sliding contact surfaces.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In Figs. 1(A) and 1(B) of the drawings, an embodiment of the present invention is shown in which the sliding contact surfaces thereof are incorporated in a power supply circuit breaker constituted by movable conductors in slidable contact with fixed conductors. In particular, the reference numeral 1 designates fixed contactors, each of which is constituted by a fixed conductor 2 made of a copper material and secured on a casing of the circuit breaker (not shown) by screws or other suitable connectors (not shown) and a contact 3 attached on the front end of the fixed conductor 2. The reference numeral 4 designates movable contactors, each of which is

constituted by a movable conductor 5 made of a copper material and driven by a switching mechanism (not shown), so as to undergo pivotal movement for switching, and a contact 6 attached on the front end of the movable conductor 5. The reference numeral 7 designates holders of an insulating material for holding the respective movable contactors 4, and the reference numeral 8 designates fixed conductors connected to a heating body of an overcurrent tripping apparatus (not shown).

Each of the fixed conductors 8 is constituted by an L-shaped conductor 9 which is upright and fixed by a screw (not shown) on the casing. An L-shaped conductor 10 is horizontally coupled with the conductor 9, and an S-shaped conductor 11 is coupled with the conductor 10 in parallel with the latter. The conductors 10 and 11 define forked arms which make sliding contact with the movable conductor 5 sandwiched therebetween as shown in the drawing.

A support shaft 12 for rotating the movable conductor 5 is inserted through the movable conductor 5 and the conductors 10 and 11, and is held at its opposite ends by the holders 7. Compression springs 13 are inserted between the conductors 10 and 11 and the holders 7, respectively, to press the conductors 10 and 11 against the movable conductor 5. The reference numeral 14 designates a contacting spring inserted between the rear end of each movable conductor 5 and the casing so as to urge the movable conductor 5 counterclockwise in the drawing to generate contact pressure between the fixed and movable contacts 3 and 6.

In the conducting state illustrated, current flowing from the fixed contactor 1 into the movable contactor 4, flows into the fixed conductor 8 through the conductors 10 and 11 by way of sliding contact portions or regions represented in Fig. 1(A) by dashed line ovals 15. Such current then flows into a load side terminal plate through the overcurrent tripping apparatus (not shown). When an operating handle (not shown) is operated, or if the overcurrent tripping apparatus performs a tripping operation, the switching mechanism (not shown) operates so that the movable contactors 4 are rapidly pivoted to rotate clockwise, as shown in Fig. 1(B), with the respective support shafts 12 as fulcrums. During such movement, the movable conductor 5 and the conductors 10 and 11 are slid relative to each other in each of the sliding contact portions 15.

According to the present invention, at least one of the sliding contact surfaces in each the regions 15 is coated with a composite in which C is dispersed in an Ag matrix. Carbon has superior lubricity, good conductivity, and does not melt together with Ag. When a coating film in which C powder is dispersed in an Ag matrix is formed on a sliding surface, therefore, galling is inhibited and the contact resistance during sliding movement of the contact surfaces is maintained at a low level. Further, even when the contact surfaces are heated by large current, surface fusion or welding is inhibited, so that the sliding contact surface remains smooth and current conduction remains stable continuously.

Thus, in the present invention, the contact resistance during

sliding movement of the mating surfaces is kept low to suppress heat generation due to conduction current and to reduce mechanical sliding abrasion. As a result, a sliding contact having large capacity for current conduction and a long life can be obtained. Further, heat generation is maintained at such a low level that the contact force can be reduced. Thus, the spring mechanism for applying the contact force and the drive mechanism for operating the contact may be of reduced capacity, making it possible to reduce the size of the overall equipment in which the invention is used.

The following examples of the composite material used in the practice of the invention will facilitate an understanding of the invention.

Example 1

In the movable contactor portions 15 of the exemplary circuit breaker described, a coating film, having a thickness of 7 μm and made of composite of Ag and C in which C was dispersed in an Ag matrix in an amount of 6% by volume, was formed on each of the movable and fixed conductors 5 and 8 by the following electric plating method.

Fig. 2 is an electron microscopic photograph (900 magnifications) showing the dispersed state of C in the plated coating film obtained in Example 1, black dots in the photograph being C.

A. Composition of Plating Liquid

metal silver concentration : 35g/ℓ

potassium cyanide : 110g/ℓ

potassium hydroxide : 8g/ℓ

graphite powder : 20g/ℓ

the size of C particle:

long diameter : 0.5 - 2μm

short diameter : 0.2- 0.5μm

dispersant for dispersing graphite powder in plating liquid : 200ppm

B. Plating conditions

anode : silver plate

bath temperature : 20°C

current density : 1A/dm^2

agitation : yes

Example 2

A coating film having a thickness of 7 μm and made of Ag and 30%C (volume percent) was formed on each of the movable and fixed conductors 5 and 8 in the same manner as in Example 1. The plating condition in this case was the same as that of Example 1 except that the bath temperature was 35°C and the long and short diameters of C particles were 0.8 - 5 μm and 0.3 - 1 μm respectively.

Comparative Examples

As comparative examples, prepared were two sliding contacts in which the movable and fixed conductors 5 and 8 were plated with Ag by 7 μm in the same manner (Comparative example 1), and in which grease was applied onto the movable and

fixed conductors 5 and 8 (Comparative Example 2).

Comparative Test Results

The movable and fixed conductors 5 and 8 were incorporated into a circuit breaker, and a no-load switching test and a large current cut-off test were conducted. In the no-load switching test, pivotal reciprocation conductor 5 was repeated to effect sliding at the contact portions 15. In the large current cut-off test, the contact portions 15 were maintained in the current conduction state. Table 1 shows the results of the test.

As may be seen from Table 1, in the sliding contacts plated with the Ag-C composite material of the invention, the foundation copper was not exposed. The sliding contacts generally plated with Ag and the sliding contacts to which grease was applied onto the plating coating film were noticably worn under the same or less strenuous test conditions as shown in the table.

Table 1

	surface coating	no load switching test	large current cut-off test
Embodiment 1	Ag-6%C	no exposure of copper after 10,000 times switching	no exposure of copper in cutting off 30 KA current
Embodiment 2	Ag-3%C	the same as above	the same as above
Comparative Example 1	Ag	exposure of copper after 2,000 times switching	exposure of cupper in cutting off 20 KA current
Comparative Example 2	Ag grease coating	exposure of copper after 10,000 times switching	exposure of cupper in cutting off 25 KA current

Fig. 3 shows measurement results of the contact resistance of the sliding contact portions 15 when the sliding contacts of Example 1 and Comparative Examples 1 and 2 were slid under a DC current load of 10A. Although there was only a small difference in the contact resistance in the stationary state among three sliding contacts, during sliding movement, the contact resistance of the sliding contact plated with a composition of Ag-6%C was the lowest and the fluctuation of the contact resistance was the smallest. Generally, the temperature of the electric contacting portion of a contact is proportional to the voltage, that is, - current x contact resistance - of the contactor portion. Therefore, the temperature in the current conduction state during

sliding movement of the contacting surfaces is the lowest in the case of the sliding contact coated with the composition of Ag-6%C.

Although two examples have been described as to the sliding contact in a circuit breaker of the foregoing embodiment, the effects of the present invention depend on the property of C, and therefore the volume %C and the particle size of C are not limited to those mentioned above. Since the degree of galling in the sliding contact portion and the degree of fusion of the same are influenced also by the area and surface pressure of the contact portion, the volume %C and the particle size of C must be determined on the basis of all the factors. Although C has conductivity, the electric resistance thereof is hundreds or thousands times as high as that of Ag. Therefore, it is not desirable to increase unnecessarily the volume %C or to use C particles having a size which is so large as to pass through the plating thickness because heat generation in the sliding contact portion is increased.

Although the coating film is formed by electric plating in the foregoing embodiment, it is important that the coating film is made of a composite of Ag and C and, therefore, the coating film forming method is not limited to electric plating.

Since prevention of galling or prevention of welding is provided by the existence of C in the sliding contact surface, the same effects can be obtained also when a coating film of Ag-C is formed on only one of the movable and fixed conductors. In this

case, although it is desirable that the non-coated member is plated with Ag, the current conduction characteristic can be obtained to a certain extent even where copper because C has an oxidation preventing capability. Further, it is not necessary that the coating film is formed on the whole surface of the conductors, but only that it be formed on the sliding contact surface regions.

Moreover, if hard fine particles such as Sic, WC, ZrB, Al_2O_3, ZrO_2, Cr_2O_3, TiO_2, R_2O_3, ThO_2, Y_2O_3, MoO_3, W_2C, TiC, B_4C, CrB_2, or the like, are dispersed in Ag-C as the third particles, the hardness of the whole coating film is increased, thereby to make it possible to obtain a long life contact surface which is less likely to be worn away.

The plating condition is such that a fundamental bath may be used with a range of plating liquid compositions in which the metal silver concentration is 2 - 100g/l, the content of potassium cyanide is 2 - 250g/l, and the content of potassium hydroxide is 0.5 - 15g/l, and graphite powder can be used within the range of 1 - 550 g/l. The diameter of graphite may be 0.05 - 25 μm, preferably, 0.2 - 10 μm.

The foregoing description of preferred embodiments of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and modifications and variations are possible in light of the above teachings or may be

acquired from practice of the invention. The embodiments were chosen and described in order to explain the principles of the invention and its practical application to enable one skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto, and their equivalents.

CLAIMS:

1. A movable electrical contactor having a surface thereof in slidable contact with a mating conductor, the surface being coated with a composite material in which particles of graphite (C) are dispersed in a matrix of silver (Ag).

2. A movable electrical contactor having a surface thereof in slidable contact with a mating conductor, said surface being coated with a composite material in which particles of graphite (C) are dispersed in a matrix of silver (Ag), characterized in that the coating film is formed by electric plating using a plating liquid comprising:

metal silver in the range of 2 - 100g/ℓ in concentration, potassium cyanide in the range of 2 - 250g/ℓ, potassium hydroxide in the range of 0.5-15g/ℓ, graphite powder in the range of 1 - 55g/ℓ, and a dispersant for dispersing graphite powder into plating liquid in the range of 10 - 2000ppm.

3. A movable electrical contactor according to Claim 2, in which hard fine particles selected from the group essentially consisting of Sic, WC, ZrB, Al_2O_3, ZrO_2, Cr_2O_3, TiO_2, R_2O_3, ThO_2, Y_2O_3, MoO_3, W_2C, TiC, B_4C, CrB_2, or the like, are dispersed in the Ag-C composite material.

4. A movable electrical contactor having a surface thereof in slidable contact with a mating conductor substantially as hereinbefore described.

Patents Act 1977
Examiner's report to the Comptroller under
Section 17 (The Search Report) CORRECTED

Application number

9121240.7

Relevant Technical fields

(i) UK Cl (Edition K) H2E, H1N, H2A, C7B

(ii) Int Cl (Edition) H01R, H01H, C25D

Search Examiner

J BANNISTER

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Date of Search

3 MARCH 1992

Documents considered relevant following a search in respect of claims ALL

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2154064	[RAU] See page 1, lines (14-18)(45-50)(56-66) (90-102), page 2, lines (59-64)	1
X	GB 1534429	[SIEMENS] See page 1, lines (9-22)	1
X	GB 1182491	[SOC. LE CARBONE LORRAINE] See page 1, lines (20-26) (50-54) and the Example	1
X	GB 839044	[MYCALEX] See page 4, lines (85-92)	1
X	US 1986224	[SANDERS] See page 1, column 2, line 49 - page 2, column 2, lines (1,2), and Figure 3	1
X	* JP 020153076 A	[AGENCY OF IND. SCI. TECH] See abstract provided by WPI	1
X	SU 000875491 A	[SARAT POLY.] See abstract provided by WPI	1
	THE ABOVE ARE EXAMPLES ONLY		

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Category	Identity of document and relevant passages	Relevant to claim(s)

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